RESPONSE OF FINISHER JAPANESE QUAILS (*CORTUNIX CORTUNIX JAPONICA*) TO ENZYME-SUPPLEMENTED SUGARCANE SCRAPPING MEAL-BASED DIETS AND COST IMPLICATION

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ABSTRACT

The study investigated the response of finisher Japanese quails (Cortunix cortunix japonica) to enzyme-supplemented sugarcane scrapping meal-based diets and the cost implication using 400 three weeks-old Japanese quails in a 3 week experiment. The birds were randomly allocated to 6 experimental diets T_{10}, T_{10}100, T_{10}200, T_{15}, T_{15}100 and T_{15}200 which were compounded to be isonitrogenous (23% crude protein) and isocaloric (2900 Kcal/Kg ME). Treatments T_{10}, T_{10}100, and T_{10}200 contained 10% crude fibre (normal fibre level) while treatments T_{15}, T_{15}100 and T_{15}200 contained 15% crude fibre level (high fibre level). The exogenous enzyme was included at 0, 100 and 200ppm thus, treatments T_{10} and T_{15} contained 0ppm, T_{10}100 and T_{15}100 contained 100ppm and T_{10}200 and T_{15}200 contained 200ppm of the enzyme supplementation such that treatments T_{10} and T_{15} served as the control for treatments T_{10}100, and T_{10}200 and T_{15}100 and T_{15}200 for low and high fibre diets, respectively. The birds were randomly allocated to the six dietary treatments at rate of 80 birds per diet in a 3 week experiment. Each treatment was replicated 4 times in a 3x2 factorial arrangement having 20 birds per replicate. The growth response parameters taken included body weight, feed consumption, weight gain, feed conversion ratio and protein efficiency ratio (PER) while the prevailing market prices of feeding stuffs were used to compute the cost benefit analysis. There was no significant variation in the growth parameters due to enzyme supplementation on growth rate and cost benefit except for water intake (126.20 vs. 142.10 and 106.26 ml/day), dietary fibre reduced final live weight, daily weight gain, protein efficiency ratio, FCR, water intake and cost benefit parameters but improved daily feed intake (21.93 and 27.94g/bird/day).The interactive effects of dietary fibre and enzyme supplementation did not influence growth rate and cost benefit parameters. From the conditions of this study, sugarcane scrapping can replace conventional energy sources to a level that is economically beneficial and nutritionally safe in quail production if arabinoxylanase is supplemented at 100 ppm.

Keywords: Maxigrain$^{(R)}$, Japanese finisher quails, growth rate, sugarcane scrapping meal, cost benefit and dietary fibre.

INTRODUCTION

The shortage and high price of animal protein have been aggravated by the high cost of conventional feed ingredients. The current high cost of commercial feeds is well known and reported (Oruseibio and Omu, 2000; Alokan, 2000; Ikani and Adesehinwa, 2000; Babatunde *et al.*, 2000; Iyeghe-Erakpotobo and Muhammad, 2004). Adegbola (1989) reported that feed accounts for 60-80% of production cost of monogastric animals in developing countries compared to about 50-65% in developed countries. The low level of cereal and oil seed production and processing, the ravaging effects of drought and the competition from direct human consumption have all contributed to the high cost of feed, which in turn has led to folding up of many poultry farms, especially small and medium-scale farms, and consequently the general decline in livestock production.

Nutritionists have the long-term challenge for research into least cost rations in order to sustain the farmers in production (Oruseibio and Omu, 2000). These workers have reported that the challenge is ever-increasing due to the current economic problems in Nigeria. The incorporation of agro-industrial by-products into animal feeds holds tremendous potentials for alleviating the short supply and high cost of feed (Babatunde *et al.,* 2000). Therefore, the use of unconventional feedstuffs as substitutes for grains and other feedstuffs have been suggested thus, the search for non-conventional feedstuffs has been the most active area of animal nutrition research in the tropical world (Ikani and Adesehinwa, 2000). Many of these agro- industrial by-products are fibrous in nature and their use in monogastric farm animal diets is therefore limited due to the fibre handling abilities of the livestock, which is about 5–7 percent (NRC, 1977; Olomu, 1979).

Fibrous food ingredients are in abundant supply and cheaply too (Dogari, 1984). Efforts at evaluating the nutritional value of these by-products such as rice offal, maize offal, wheat offal and brewer's spent grains have been in progress for sometime in Nigeria with significant achievements (Babatunde *et al.,* 1975; Adebowale and Ademosun, 1981). These fibrous feedstuffs have been shown to result in increased feed intake, lowering the rate of live weight gain and in poorer feed conversion ratios when they replaced maize in diets (Nelson, 1984; Maisamari, 1986; Atteh *et al.,* 1993; Tuleun *et al.*, 1998; Oluolokun and Olaloku, 1999).

This is attributable to non-ruminant animals' lack the enzyme cellulase that can digest the components of the fibre in rice offal and other fibrous by products. This is so, at least in the small intestinal tract, which is the site for most nutrient absorption (Holness, 1991).

There is evidence that pre-digestion or any attempt to initiate the hydrolysis of feed components often enhances the digestibility and utilization when fed in animal diets. One of such techniques is the use of exogenous enzyme preparations with feedstuff (Bio–Ingredients Ltd, 2004). Although the use of commercial feed enzymes has gained world – wide acceptability, its use in Nigeria is still not popular. The use of exogenous enzymes is known to help in the digestibility of feed ingredients and allow for the use of cheaper and poorer quality materials to obtain optimum performance.

There is a sizeable body of literature on the value of enhanced digestibility of roughages through the use of these enzymes with favourable results on growth performance, feed conversion efficiencies and on profitability of the enterprise (Broz and Frigg, 1993; Viveros *et al.,* 1994; Tuleun *et al*., 1998). The use of enzymes has been common in many industries for some years. For instance, enzyme uses in the food processing, brewing and leather-working industries are well documented (Partridge and Wyatt, 1995). An increased understanding of the properties of enzymes and their function has led to their introduction in the animal-feed industry which has led to increased application of enzyme technology in the livestock feed industry.

Enzymes have been approved for use in poultry feed because they are natural products of fermentation and therefore pose no threat to the animal or the consumer, (Vukic Vranjes and Wenk, 1993). Their use in poultry feeds has predominantly been related to the hydrolysis of fibre or non-starch polysaccharide (NSP) fraction of cereal grains. These NSPs cannot be digested by the endogenous enzymes of poultry and can have anti-nutritive effects as they cause an increase in viscosity of intestinal content and entrap large amounts of well digestible nutrients like starch and proteins. This leads to an impaired digestion and digestive problems, (Almirall *et al.,* 1995).

Numerous researchers have demonstrated that the soluble NSP fraction and not the total NSP fraction are responsible for anti-nutritive responses. These NSPs can bind to large amounts of water and as a result, the viscosity of fluids in the digestive tract is increased. The increased viscosity causes problems in the small intestines because it reduces nutrient availability (particularly fat) and results in increased amount of sticky droppings (Choct *et al.*, 1995).

Japanese quails (*coturnix coturnix japonica*) are small bodied birds of the galliforme family, since their introduction into the Nigerian poultry industry in 1992 (Haruna *et al.*, 1997), they have gained tremendous interest among Nigerian populace especially because of their short generation interval, fast growth rate and less susceptibility to common poultry diseases. Japanese quails in the wild, feed on insects, grains, grasses and various seeds. They have also been found to thrive well and grow efficiently in captivity when fed high protein diets (NVRI, 1996). Nevertheless, little research work has been done in the area of comparative ingredient evaluation for quail birds since the need for poultry species with lesser demand and low cost of production is more realistic when feed ingredients that are less competitive and available are used. This is the reason for considering sugarcane scrapping meal as an alternative feed source in quail diet. The aim of the study is therefore, to investigate the effects of exogenous enzyme supplementation of sugarcane scrapping meal-based diets on the growth rate and cost implication of finisher Japanese quails.

Materials and Methods

Study area

The experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture, Nasarawa State University, Keffi, Shabu – Lafia Campus. It is located in the guinea savanna zone of North Central Nigeria. It is found on latitude 08^0 35'N and longitude 08^0 33' E. The mean monthly maximum and minimum temperatures are 35.06 and 20.16^0C, respectively while the mean monthly relative humidity is 74%. The rainfall is about 168.90 mm. (NIMET, 2008)

Sugarcane scrapping

Sugarcane scrapings were sourced from local sugarcane marketers within Lafia metropolis, sun-dried and milled to form the sugarcane scrapping meal.

Source of Maxigrain® enzyme

Maxigrain® enzyme a multi-enzyme compound of β-glucanase, xylanase, phytase, arabinoxylanase and a mixture of yeast and minerals was purchased from Animal Care, Abuja.

Biochemical analysis

The proximate analysis of sugarcane scrapings, basal, experimental diets and faecal samples of the experimental birds were done at the International Institute for Tropical Agriculture (IITA) Ibadan, using the procedure outlined by AOAC (1990) while the fibre fractions namely neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) were determined by methods of Vansoest and Robertson (1985) and the values reported on a dry matter basis.

Description of diets and experimental design

Six experimental diets tagged T_{10}, T_{10}100, T_{10}200, T_{15}, T_{15}100 and T_{15}200 were compounded to be isonitrogenous (23% crude protein) and isocaloric (2900Kcal/Kg ME) with two levels of crude fibre. The birds were randomly allocated to the treatments at rate of 80 birds per diet in a 3 week experiment. Each treatment was replicated 4 times in a 3x2 factorial arrangement having 20 birds per replicate. Treatments T_{10}, $T_{10}100$, and $T_{10}200$ contained 10% crude fibre while treatments T_{15}, $T_{15}100$ and $T_{15}200$ contained 15% crude fibre level (high fibre level). The exogenous enzyme was included at 0, 100 and 200ppm thus, treatments T_{10} and T_{15} contained 0ppm, $T_{10}100$ and $T_{15}100$ contained 100ppm and $T_{10}200$ and $T_{15}200$ contained 200ppm of the enzyme supplementation such that treatments T_{10} and T_{15} served as the control for treatments $T_{10}100$, and $T_{10}200$ and $T_{15}100$ and $T_{15}200$ for low and high fibre diets respectively. Table 1 shows the gross composition of the experimental diets for finisher quails.

Management of experimental birds

The birds were fed *ad-libitum* and had access to drinking water at all times. Lighting source was provided using electricity bulbs during the night. The birds were administered anti-stress vitamin/mineral premix orally at the recommended dosage after the randomization before the commencement of the experiment. The birds were housed in a deep litter pens constructed using wire mesh to allow for adequate ventilation. Other routine management practices were adopted as outlined by Musa *et al.* (2007).

Data collection

The growth performance included body weight gain which was computed as the difference between the final weight and the initial weight of the birds, feed intake determined as the difference between the amount of feed fed and the leftover. Feed conversion ratio was calculated as the rate of feed intake to live weight gain while protein efficiency ratio was computed as the as the gain in body weight to the protein consumed. Water consumption determined accounting for evaporative loss using the procedure outlined by Shoremi *et al.* (2001). Mortality record was kept throughout the experimental period.

Statistical analysis

Data obtained were subjected to Two Ways Analysis of Variance (ANOVA). The separation of means was effected using Least Significant Difference (LSD) method and tested at probability level of 5% as described by Steel and Torrie (1980). The following statistical model was used:

$$Y_{ij}=\mu+A_i+B_j+(AB)_{ij}+€_{ijk}$$

Where Y_{ij} = Individual observation

μ = general Mean

A_i =effect of Factor A

B_j =effect of Factor B

$(AB)_{ij}$=effect of interaction AB

$€_{ijk}$=experimental error

Results and Discussion

Table 2 shows the proximate composition of sugarcane scrapping. The calculated metabolizable energy from the proximate composition data using the formula as described by Pauzenga (1985) ME (kcal/kg) = 37x % CP x 81.1 x % EE + 35.5 x % NFE was about 29070.45. The test ingredient contains low (8.25%) crude protein, high crude fibre (36.48%) and low (3.36%) either extract. The dry matter was about 90.67% while ash and nitrogen free extract were about 9.98 and 67.40% respectively. This composition makes sugarcane scrapping a fibrous feed material which will require some level of processing or pre-digestion such as milling and or enzyme supplementation if it must be fed to monogastric animals.

Table 3 shows the analyzed diets for the finisher quail. The chemical composition of the experimental diets for finisher quail: 22% CP and 2800 Kcal/ME/kg diet were adequate for quails within this age group (Farell *et al.*, 1973; Bawa, 2012). The crude fibre values were 10% for diets $T10_0$, $T10_{100}$ and $T10_{200}$ and about 15% for diets $T15_0$ $T15_{100}$ and $T15_{200}$. The crude fibre level increased as the level of sugarcane scrapping meal increased in the diets. The fibre fractions and mineral content of the diets were adequate for finisher quails (Musa *et al*., 2007).

The non-significant variation in the final live weight, daily weight gain, daily feed intake, feed conversation ratio, protein efficiency ratio (Table 4) except for water intake which increased significantly (P<0.05) with enzyme supplementation (126.20 vs. 142.10 and 106.26ml/day), feed cost per weight gain, cost of production, revenue and gross margin due to enzyme supplementation implies that enzyme supplementation improved the utilization of fibrous feeds although there was significant variation in daily weight gain. These observations are in agreement with the report of Makanjuola and Iyayi (2010) who investigated the utilization of maize bran-based diets supplemented with Raxazyme G2G by broiler and observed that increased weight gain and feed intake were noted in birds fed the enzyme supplemented diets. This could be attributed to the fact that Maxigrain® enzyme broke down the fibre component in the feed thereby making available the nutrients to the birds. This is also in line with the earlier report that enzyme (Raxazyme G) complements the digestive enzyme of poultry to enhance the utilization of non-starch polysaccharides in cereals and their by products (Atteh *et al.,* 1993). The values reported in this study were slightly higher than the values of 1.58-1.78 g as earlier reported by Tuleun *et al.* (2009); but close to 3.08-3.32 g/bird/day as reported by Chantiratikul *et al.* (2010) for weight gain. Dietary fibre reduced (P<0.05) final live weight (132.90 and 118.70 g/bird), daily weight gain (3.70 and 3.03g/bird/day), improved PER (0.73 and 0.46), water intake (138.41 and 119.22ml/bird/day) but reduced FCR (6.12 and 9.44) (Tables 5). Similarly, the cost benefit analysis parameters evaluated were significantly reduced (P<0.05) implying reduction in feed cost, as a result of the low cost of sugarcane scrapping. The result obtained confirms that Maxigrain® supplementation is suitable only with the use of feeds that exceed the recommended dietary fibre levels for optimum growth.

There was no significant difference (P>0.05) in the growth rate and cost benefit analysis due to the interactive effects of enzyme supplementation and dietary fibre (Tables 6). This observations are similar to the findings of Duru and Dafwang (2010) who investigated the effect of Maxigrain® enzyme supplementation of diets with or without rice offal on the performance of broiler chicks and noted that there was no significant variation in final body weight gain but feed intake was influenced significantly due to rice offal inclusion. Generally, birds tend to eat more feed when the level of fibre increases in the diets; this is in order to meet the calorie requirement of the bird which was in line with the trend recorded in this study. The values obtained in this study were within the range of 12.53-13.91g/bird/day for feed intake as reported by Bawa (2012a). Feed conversion ratio was better for chicks fed the low fibre diets and is an indication that chicks ate less to put a unit weight since the low fibre is a reflection of high energy density in the diets. The values obtained in the present study were close to the 12.53-13.91g/bird/day, 3.36-3.83 g/bird/day, and

3.27-3.84 for final weight, weight gain and feed conversation ratio earlier reported (Bawa, 2010).

Conclusion and Recommendation

Based on the findings of this experiment, supplementing high level (15%) of sugarcane scrapping meal-based diets with Maxigrain® enzyme at 100pp is safe and economical and is recommended for inclusion in the diets of finisher quails.

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Table 1. Gross composition of experimental diets for finisher quails

Feedstuffs (%)	EXPERIMENTAL DIETS					
	$T10_0$	$T10_{100}$	$T10_{200}$	$T15_0$	$T15_{100}$	$T15_{200}$
Maize	32.90	32.90	32.90	-	-	-
Soybeans(Fullfat)	20.00	20.00	20.00	21.98	21.98	21.98
Groundnut cake	22.00	22.00	22.00	23.85	23.85	23.85
SCM[1]	19.20	19.20	19.20	46.85	46.85	46.85
Bone meal	2.00	2.00	2.00	1.00	1.00	1.00
Blood meal	2.85	2.85	2.85	3.55	3.55	3.55
Palm oil	-	-	-	1.72	1.72	1.72
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25	0.25
Enzyme (ppm)	-	100	200	-	100	200
Total	**100:00**	**100:00**	**100.00**	**100:00**	**100:00**	**100:00**
Calculated chemical and energy composition						
Energy (Kcal/kg ME)**	2971.90	2971.90	2971.90	2900.58	2900.58	2900.58
Crude protein (%)	23.25	23.25	23.25	23.33	23.33	23.33
Crude fibre (%)	10.20	10.20	10.20	15.00	15.00	15.00
Calcium (%)	0.89	0.89	0.89	0.74	0.74	0.74
Phosphorus (%)	0.73	0.73	0.73	0.56	0.56	0.56
Feed cost/kg (₦/kg)	87.80	87.98	88.15	71.92	72.10	72.27

[1]SCM-sugarcane scraping meal

*The vitamin – mineral premix supplied the following per 100kg of diet: Vitamin A, 15,000 I.U; Vitamin D_3, 300,000 I.U; Vitamin E 3,000 I.U; Vitamin K, 2.50mg; Thiamin (B_1), 200mg; Riboflavin (B_2), 600mg; Pyridoxine (B_6), 600mg; Niacin, 40.0mg; Vitamin B_{12}, 2mg; Pantothenic acid, 10.0mg; Folic acid, 100mg; Biotin, 8mg; Choline chloride, 50g; Anti oxidant, 12.5g; Manganese, 96g; Zinc, 6g; Iron, 24g; Copper, 0.6g; Iodine, 0.14g; Selenium, 24mg; Cobalt, 214mg.

**Pauzenga (1985): ME kcal/ kg = 37 X %CP + 81.1 X %EE + 35.5 X NFE.

Table 2. Proximate and energy composition of sugarcane scrapping

Nutrient	%
Crude protein	8.25
Crude fat	3.36
Crude fibre	36.48
Ash	9.98
Dry matter	90.67
NFE	67.40
[a]Energy (Kcal/kg ME)	2970.45

[a]Calculated from Pauzenga (1985)

Table 3. Proximate and chemical composition of finisher quails (*Cortunix cortunix japonica*) diets (%)

Nutrients	T10	$T10_{100}$	$T10_{200}$	T15	$T15_{100}$	$T15_{200}$
DM	89.26	89.28	89.71	89.14	89.95	89.03
CP	22.58	22.70	23.30	23.09	23.40	23.04
CF	10.21	10.16	10.13	15.27	15.78	15.38
EE	4.26	4.06	3.76	3.71	4.27	2.76
Ash	7.42	6.79	6.69	6.91	6.63	7.78
NFE	55.53	66.45	56.12	51.02	49.92	51.04
NDF	47.18	59.38	57.35	63.59	55.18	61.43
ADF	36.24	37.68	36.79	42.86	36.43	40.26
ADL	11.87	12.59	13.09	12.79	12.21	14.37
Hemicellulose	10.94	21.70	20.56	20.73	18.75	21.17
Cellulose	24.37	25.09	23.70	30.07	24.22	25.89
[a]Calcium	0.89	0.89	0.89	0.84	0.84	0.84
[a]Phosphorus	0.73	0.73	0.73	0.71	0.71	0.71
[b]Energy (Kcal/kg ME)	2852.26	2873.14	28159.30	2866.42	2884.26	2888.24

DM-Dry matter, **CP-**Crude protein, **CF-**Crude fibre, **EE-**Ether extract, **NFE-**Nitrogen-free extract**, NDF-**Neutral detergent fibre**, ADF-**Acid detergent fibre**, ADL-**Acid detergent lignin**,** [a] Calculated from NRC (1979), [b] Calculated from Pauzenga (1985)

Table 4. Effect of Maxigrain® enzyme supplementation on growth performance, water intake and economics of production of finisher quails (*Cortunix cortunix japonica*)

Performance indices	Main Treatment Means				
	No Enzyme	100ppm Enzyme	200ppm Enzyme	SEM	LOS
Av. LW (g/bird)	55.02	55.01	54.92	0.07	NS
Av. FLW (g/bird)	126.60	126.70	124.10	3.74	NS
Av. DWG (g/bird/day)	3.40	3.41	3.29	0.18	NS
Av. DFI (g/bird/day)	25.02	25.26	24.53	0.46	NS
Av. FCR	7.90	7.67	7.76	0.52	NS
Av. PER	0.61	0.59	0.58	0.03	NS
Av. WI (ml/day)	126.20 [b]	142.10 [a]	106.26[b]	13.42	*
Economics of production					
Av. FC/kg (N/kg)	79.86	80.04	80.21	-	-
Av. FC/WG(N/kg)	11.76	11.29	11.10	0.76	NS
Av. CP (N/bird)	43.90	38.60	37.80	4.36	NS
Av. Revenue (N)	680.00	681.00	658.00	35.80	NS
Av. Gross margin	644.00	641.00	620.00	31.70	NS

LW-Live weight, **FLW-**Final live weight, **DWG-**Daily weight gain, **DFI-**Daily feed intake, **FCR-**Feed conversion ratio, **PER-**Protein efficiency ratio, **WI-** Water intake, **a,b-** Means on the same row bearing different superscript differ significantly ($P < 0.05$), **NS** - No significant difference ($P > 0.05$), **LOS-** Level of significant difference, **FC-**Feed cost, **FC/WG-**Feed cost per weight gain, **CP-**Cost of production.

Table 5. Effect of dietary fibre on growth performance, water intake and economics of production of finisher quails (*Cortunix cortunix japonica*)

Performance indices	Main Treatment Means			
	Low Fibre	High Fibre	SEM	LOS
Av. LW (g/bird)	54.94	55.08	0.06	NS
Av. FLW (g/bird)	132.90 [a]	118.70 [b]	3.05	*
Av. DWG (g/bird/day)	3.70 [a]	3.03 [b]	0.15	*
Av. DFI (g/bird/day)	21.93 [b]	27.94[a]	0.38	*
Av. FCR	6.12 [b]	9.44 [a]	0.43	*
Av. PER	0.73 [a]	0.46 [b]	0.03	*
Av. WI (ml/day)	138.41 [a]	119.22 [b]	14.20	*
Economics of production				
Av. FC/kg (N/kg)	87.80	71.92	-	-
Av. FC/WG(N/kg)	14.93 [a]	7.83 [b]	0.62	*
Av. CP (N/bird)	56.80 [a]	23.40 [b]	3.56	*
Av. Revenue (N)	741.00 [a]	605.00 [b]	29.30	*
Av. GM	684.00	586.00	25.90	*

LW-Live weight, **FLW-**Final live weight, **DWG-**Daily weight gain, **DFI-**Daily feed intake, **FCR-**Feed conversion ratio, **PER-**Protein efficiency ratio, **WI-** Water intake, **FC-**Feed cost, **FC/WG-**Feed cost per weight gain, **CP-**Cost of production, **GM-**Gross margin, **a,b-** Means on the same row bearing different superscript differ significantly ($P < 0.05$), **NS** - No significant difference ($P > 0.05$), **LOS**- Level of significant difference

Table 6. Effects of Maxigrain® enzyme supplementation and dietary fibre on growth performance and water intake of finisher quails (*Cortunix cortunix japonica*)

Performance indices	Main Treatment Means							
	T10	$T10_{100}$	$T10_{200}$	T15	$T15_{100}$	$T15_{200}$	SEM	LOS
Av. LW (g/bird)	54.93	55.08	54.82	55.11	55.11	55.02	0.25	NS
Av. FLW (g/bird)	140.30	133.0	125.20	112.80	120.40	122.90	5.29	NS
Av. DWG (g/bird/day)	4.06	3.71	3.35	2.74	3.11	3.23	0.25	NS
Av. DFI (g/bird/day)	21.54	22.38	21.88	28.50	28.15	27.19	0.66	NS
Av. FCR	5.35	6.06	6.96	10.46	9.28	8.57	0.74	NS
Av. PER	0.83	0.71	0.66	0.41	0.47	0.51	0.05	NS
Av. WI (ml/day)	129.32	198.40	182.44	127.50	144.10	140.11	21.12	NS
Mortality (%)	15.00	5.00	0.00	10.00	5.00	5.00	-	-
Economics of production								
Av. FC/kg (N/kg)	87.80	87.98	88.15	71.92	72.10	72.27	-	-
Av. FC/WG(N/kg)	16.60	14.62	13.59	6.93	7.97	8.61	1.07	NS
Av. CP (N/bird)	68.60	54.40	47.40	19.10	22.80	28.30	6.16	NS
Av. Revenue (N)	812.00	741.00	670.00	548.00	621.00	646.00	50.70	NS
Av. GM	743.00	687.00	622.00	544.00	596.00	618.00	44.80	NS

LW-Live weight, **FLW-**Final live weight, **DWG-**Daily weight gain, **DFI-**Daily feed intake, **FCR-**Feed conversion ratio, **PER-**Protein efficiency ratio, **WI-** Water intake, **FC-**Feed cost, **FC/WG-**Feed cost per weight gain, **CP-**Cost of production, **GM-**Gross margin, **a, b-** Means on the same row bearing different superscript differ significantly ($P < 0.05$), **NS** - No significant difference ($P > 0.05$), **LOS**-Level of significant difference.